CHANGE IN THE TERRESTRIAL INVERTEBRATE COMMUNITY STRUCTURE IN RELATION TO LARGE FIRES AT THE KUTAI NATIONAL PARK, EAST KALIMANTAN (BORNEO), INDONESIA

Takaáki Yajima
Department of Biology, College of Liberal Arts
Kanazawa University, Kanazawa 920, Japan

I. INTRODUCTION

The tropical rain forests, where plants and animals are most abundant, are the earth's remaining great treasure houses of nature. Among these tropical rain forests, the primary lowland forest of East Kalimantan (Borneo, Indonesia) is one of the most magnificent (Kira,1983). In 1982-83, however, this lowland tropical rain forest suffered by a serious drought associated with the intense El Niño (Leighton,1984, Wirawan,1984, Malingreau *et al.*, 1985).

The purpose of this study was to find out the changes in terrestrial invertebrate community structures in relation to the recovery of the forests after large fires and the significance of this for the preservation of tropical rain forests. The research was done at the Kutai National Park, East Kalimantan, from 25 July to 23 August 1986, taking into consideration the various vegetation types such as unburnt, burnt and logged forests.

II. AREA SURVEYED

The area of Kutai National Park and stations surveyed is shown in Fig. 1. After consideration of the influence of large fires and the human impact on nature, the following eleven stations were selected.

UNF: Unburnt natural *Shorea* forest at 165 to 185m above sea level near Km 37.

UNF: Unburnt natural *Dryobalanops* forest at 200m above sea near the Km 45.

USF: Unburnt secondary *Macaranga* forest at 150m above sea level near the Km 37.

BNF: Burnt natural *Shorea* forest at 245m above sea level near

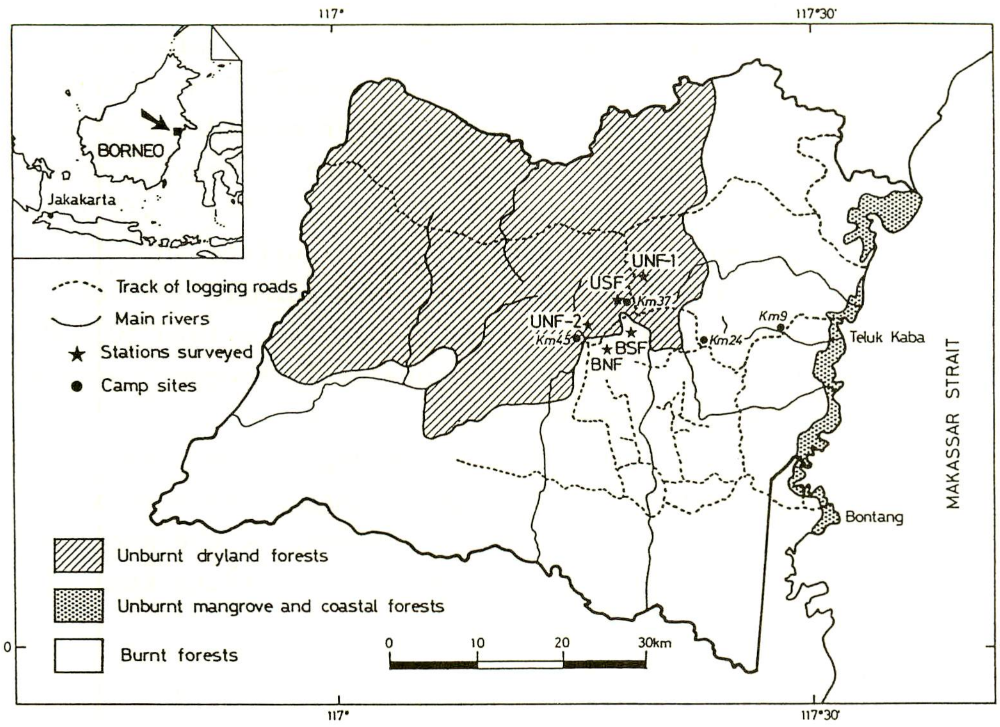

Fig. 1. Outline map and vegetations of Kutai National Park showing the stations surveyed.
UNF-1 and UNF-2:Unburnt natural forests
USF:Unburnt secondary forest
BNF:Burnt natural forest
BSF:Burnt secondary forest
Open fields of *Melastoma* shrub (MEL) and *Imperata* grass (IMP) were surveyed also. The stations of MEL-1 and IMP-1, MEL-2 and IMP-2, and MEL-3 and IMP-3 located near USF, BNF, and BSF, respectively.

the Km 45.

BSF: Burnt secondary *Omalantus, Croton* and *Mallotus* forest at 245 to 280m abobe sea level.

MEL: Open fields of *Melastoma* shrub along logging roads. Three stations of MEL-1, -2 and -3 were selected near USF, BSF and BNF, respectively.

IMP: Open fields of *Imperata* grass along logging roads. Three stations of IMP-1, -2 and -3 were selected near USF, BSF and BNF, respectively.

III. METHODS

1. Macro soil-animals

The density and biomass of macro soil-animals whose body sizes exceed 2mm were studied. Four quadrats of 50 x 50cm were set on flat floor at each station after consideration of the microtopography. From the results of preliminary research at UNF, it was found that fermentation of the soil layer was lacking and macro soil-animals were found only in a surface soil layer of 10cm in depth. Therefore, the macro soil-animals in each layer of litter (L), humus (H), and surface soil (A) within 10cm depth were collected by hand sorting with tweezers. However, ants were excluded because of the numerous numbers found.

As the surface soil which had been dug up contained a great deal of clay, it was very hard to put through a 2mm mesh sieve in order to collect the soil animals. Therefore, the macro soil-animals had to be found in the soil after cutting the soil by hand.

2. Floor animals

The floor invertebrates were collected quantitatively using a pitfall trap. At each station, eight plastic cups (10cm in height and 7.5cm in caliber) were sunk about 5m apart from one another in the ground so that the rims were on the level of the soil or letter surface. A little water was put into each cup so that the animals trapped could not escape easily from the cup.

Many cursorial arthropods which had fallen into the traps were collected on each of three mornings after setting.

3. Phytal animals

Phytal invertebrates were collected quantitatively at each station by the sweeping method.

The sweeping was done with a sweep net of 42cm in diameter having a wooden handle of 130cm in length. The sweepings were done ten times at each station, and the invertebrates collected were killed with etyle acetate.

All the samples collected by these various methods were sorted by species in the laboratories at Km 37 and Bontang, and were preserved in vials, plastic tubes and small plastic pouches with 70 per cent alcohol, except for almost all of the insects, which desiccated instead.

After weighing the biomass of macro soil-animals, all

Table 1. Number of species and percent composition (in parentheses) of macro soil-animal communities at each station. For abbreviations, see Fig. 1.

Animals	UNF-1	UNF-2	USF	BNF	BSF	MEL-1	MEL-2	MEL-3	IMP-1	IMP-2	IMP-3
Turbellaria	1(0.8)										
Gastropoda	6(4.9)	1(1.2)	2(2.2)		4(7.1)	5(5.5)		1(1.8)	1(5.0)		
Oligochaeta	59(48.0)*	41(48.8)*	63(68.5)*	44(57.9)*	36(64.3)*	64(70.3)*		3(5.5)	7(35.0)		4(50.0)
Hirudinea	1(0.8)		1(1.1)		1(1.8)						
Acarina			2(2.2)					1(1.8)			
Araneae	7(5.7)	2(2.4)		1(1.3)		1(1.1)	2(16.7)	4(7.3)			1(12.5)
Isopoda	2(1.6)	14(16.7)*	6(6.5)	2(2.6)	3(5.4)	2(2.2)					
Chilopoda	12(9.8)	6(7.1)	3(3.3)	6(7.9)	1(1.8)	2(2.2)	1(8.3)	3(5.5)	1(5.0)		
Diplopoda	6(4.9)	3(3.3)	1(1.1)	4(5.3)	2(3.6)	1(1.1)		1(1.8)			
Collembola			1(1.1)								
Thysanura				1(1.3)							
Orthoptera					1(1.8)			3(5.5)			
Dermaptera	2(1.6)	3(3.6)	2(2.2)	7(9.2)	1(1.8)						
Dictyoptera		3(3.6)	3(3.3)	3(3.9)		4(4.4)	1(8.3)	4(7.3)	2(10.0)	1(20.0)	
Hemiptera		2(2.4)				1(1.1)	1(8.3)				2(25.0)
Coleoptera	5(4.1)	2(2.4)	1.(1.1)	4(5.3)	2(3.6)	3(3.3)	6(50.0)*	23(41.8)*	9(45.0)*	3(60.0)	1(12.5)
Larva	19(15.4)*	6(7.1)	6(6.5)	4(5.3)	5(8.9)	7(7.7)	1(8.3)	11(20.0)		1(20.0)	
Unknown	3(2.4)	1(1.2)	1(1.1)			1(1.1)		1(1.8)			
No. of species	32	23	22	23	13	14	7	27	7	3	4
No. of individuals	123	83	92	76	56	91	12	55	20	5	8
β	3.642	3.865	2.039	2.938	2.150	1.770	9.429	19.655	4.500	3.333	6.000
$N\beta$	394.6	324.7	183.5	223.3	114.0	150.4	113.2	963.1	85.5	16.7	24.0

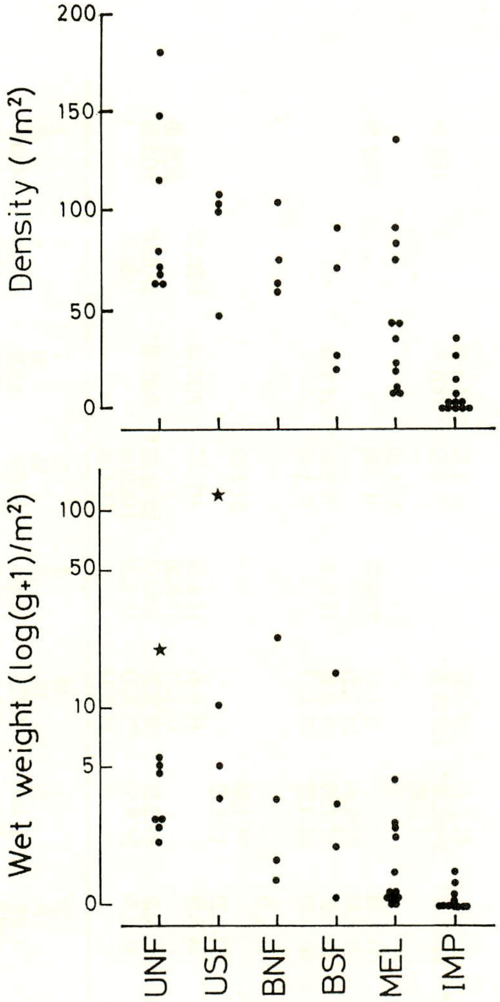

Fig. 2. Density and biomass of macro soil-animals collected in each quadrat (50x50 cm) at each station. Star symbols in UNF and USF mean the collection of one big Diplopoda, *Sphaerobelum* sp. For abbreviations, see Fig. 1.

reference species collected were submitted to specialists for identification. The identification, however, was very difficult to do in a short time. Therefore, in this report, the community structures among the stations surveyed were compared with the taxon of order or class level.

IV. RESULTS AND DISCUSSION

1. Macro soil-animals

A summary of results for macro soil-animals collected at each station is shown in Table 1.

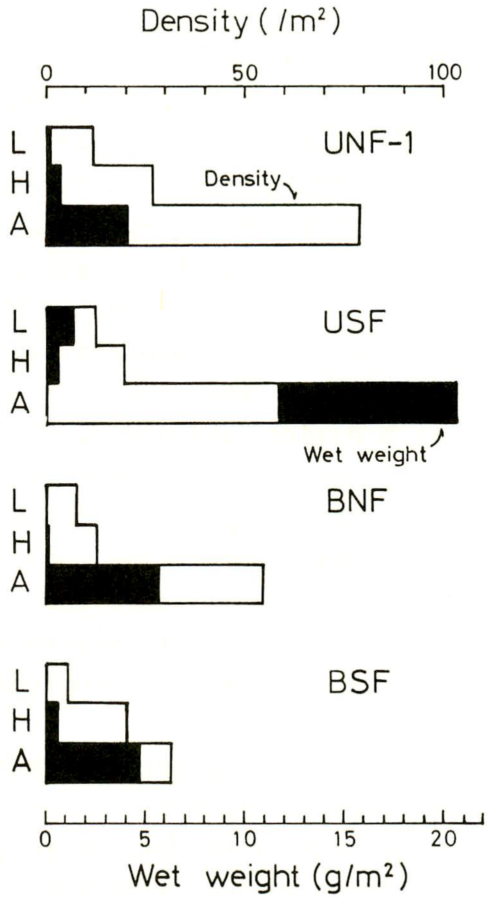

Fig. 3. Vertical change of macro soil-animals at each forest. For abbreviations, see Fig. 1.

The number of individual macro soil-animals collected at each station was very few, and so the total number of individuals was only 621. In the forests, the dominants, which are the significance with 90 per cent reliability from the mean occurrence rate (Katō, *et al.*, 1952), were earthworms Oligochaeta. On the other hand, in the open fields, the dominants, except for the Oligochaeta at MEL-1, were many kinds of Coleoptera of MEL-2 and -3, and IMP-1. Moreover, Isopoda, Diplopoda and Dermaptera, which were not dominants except for Isopoda of UNF-2, appeared, oddly enough, not in open fields but in forests. It was interesting that living land snails of Gastropoda, Collembola and Amphipoda were absent or rarely found at each station, and old dead and damaged shells were collected only on and/or in soil. This was interesting because, in temperate forests such as those of Japan, living land snails, Collembola and Amphipoda are common species of macro soil-animals. These tendencies in tropical forests were reported by Aoki and Harada (1982).

Fig. 2 shows the results of the density and biomass of macro soil-animals collected in each quadrat at various vegetations.

Generally, density and biomass decrease gradually from the unburnt forests to open fields of *Imperata* grass according to the degree of destruction of nature by means such as burning and logging. Watanabe *et al.*(1983) observed, in Northeast Thailand, a drastic decline in the density and biomass of macro soil-animals following burning. But even in the same station, the density and biomass collected at each quadrat changed widely. This was mainly due to the difference in the number of individuals and the weight of the larger earthworms collected, except two quadrats of UNF and USF where a big Diplopoda was found. The intensity and frequency of burning might affect the soil fauna and vary the ecological environment. However, the actual intensity of burning on soil fauna at each burnt forests was not known for the purposes of this research.

Fig. 3 shows the results of vertical change in macro soil-animals at some unburnt and burnt forests.

As the research was done in the dry season, the thickness of litter was 3 to 4cm of fallen leaves such as deciduous Diptero-carpus. Allmost all of the fallen leaves were in their original form without decomposition, and the fermentation layer could not be identified. A small humus layer had formed and the thickness was only a few millimeters. Therefore, the density and biomass at the litter layer were more scanty. As the earthworms and larvae of beetles appeared in increasing more from the humus to the surface soil, the density and biomass increased correspond-ingly.

These results, that the number of species and individuals, and the biomass of macro soil-animals were not great (Table 1 and Figs. 2, 3), were consistent with those found by Watanabe *et al.*(1966) in a dry season in Thailand, and Aoki and Harada (1982) in a wet season in East Kalimantan. The reasons for the poverty of the fauna and biomass may be the lack of a fermentation layer, and the fluctuations in soil moisture content (Lel,1987). Therefore, research on the seasonal changes in fauna and biomass of macro soil-animals needs to be carried out throughout the whole

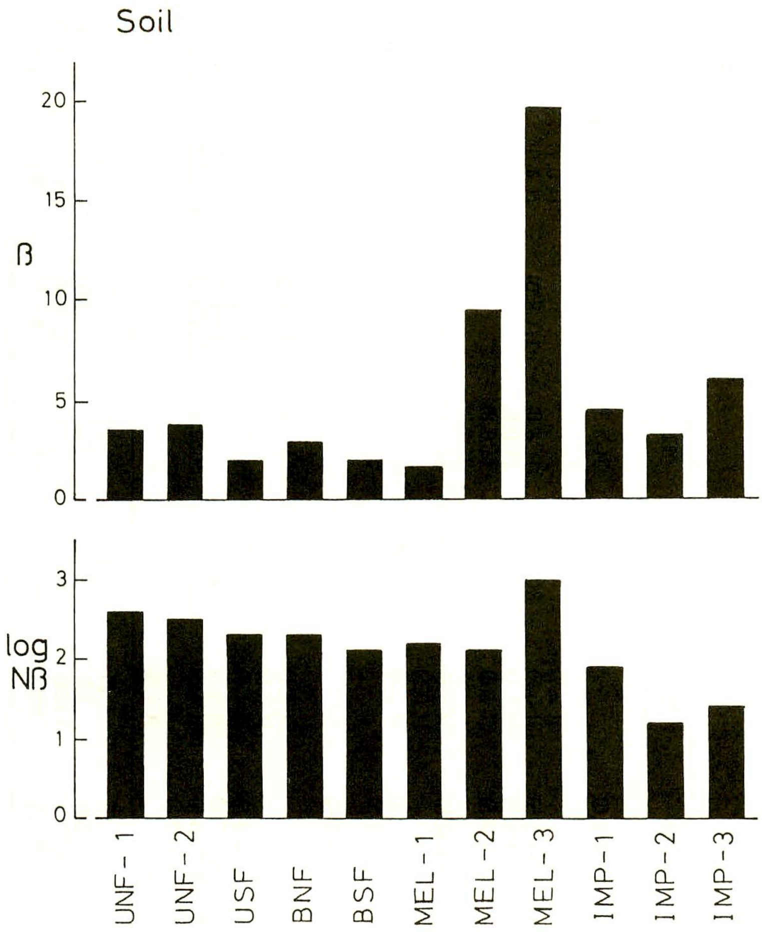

Fig. 4. Comparison of species diversity (ß) and total species diversity (Nß) of macro soil-animal communities at each station expressed by Morisita´s indexes. For abbreviations, see Fig. 1.

year.

The species and total species diversities (Morisita,1967) of macro soil-animals were compared among the stations surveyed and the results are shown in Fig. 4.

Against expectation, the value of species diversity was higher in open fields than in forests. The reason for this difference was that an earthworm with a large number of individuals was dominant in forests, and many kinds of beetle with a small number of individuals were dominants in open fields, especially at MEL-2, -3 and IMP-1.

The value of Morisita´s index of diversity correlates not only with the number of species but also with the number of individuals, and so the value is highest when the total number of

Table 2. Number of species and percent composition (in parentheses) of floor invertebrate communities at each station. For abbreviations, see Fig. 1.

Animals	UNF-1	UNF-2	USF	BNF	BSF	MEL-1	MEL-2	MEL-3	IMP-1	IMP-2	IMP-3
Gastropoda			1(1.0)								
Oligochaeta	2(1.6)	3(1.9)			2(1.0)			3(2.3)			
Opiliones	1(0.8)										1(0.4)
Acarina						5(2.7)				1(0.7)	
Araneae	5(4.0)	3(1.9)	1(1.0)	7(6.9)	3(1.5)	10(5.3)	8(3.1)	11(8.0)	11(8.0)	7(4.9)	10(3.5)
Isopoda	2(1.6)	2(1.3)	2(2.0)		1(0.5)	2(1.1)		1(0.8)			
Chilopoda			1(1.0)	(2.0)	1(0.5)	3(1.6)		1(0.8)			
Diplopoda								3(2.3)		2(1.4)	
Collembola	3(2.4)		8(8.0)	3(3.0)	25(12.5)	3(1.6)	4(1.5)	3(2.3)	6(4.4)	5(3.5)	5(1.8)
Thysanura	2(1.6)		1(1.0)			1(0.5)					
Orthoptera	4(3.2)	2(1.3)	2(2.0)	4(4.0)	8(4.0)	5(2.7)	16(6.1)	18(13.5)	12(8.8)	7(4.9)	16(5.6)
Dictyoptera					1(0.5)		5(1.9)	5(3.8)			
Isoptera				3(3.0)							
Psocoptera					1(0.5)						
Thysanoptera		1(0.6)									
Hemiptera	1(0.8)	1(0.6)				2(1.1)		5(3.8)	2(1.5)	3(2.1)	5(1.8)
Lepidoptera						1(0.5)					
Diptera	4(3.2)	5(3.2)	1(1.0)		9(4.5)	3(1.6)	5(1.9)	4(3.0)	2(1.5)	3(2.1)	2(0.7)
Coleoptera	9(7.1)	3(1.9)	8(8.0)	11(10.9)	15(7.5)	10(5.3)	1(0.4)		3(2.2)	2(1.4)	1(0.4)
Hymenoptera	91(72.2)*	134(85.9)*	72(72.0)*	71(70.3)*	133(66.5)*	140(74.5)*	223(85.1)*	79(59.4)*	101(73.7)*	113(79.0)*	245(86.0)*
Larva		2(1.3)			1(0.5)						
Unknown	2(1.6)		3(3.0)			3(1.6)					
No. of species	49	35	23	43	55	40	40	49	27	37	35
No. of individuals	126	156	100	101	200	188	262	133	137	143	285
β	6.5299	3.6328	2.2822	6.7423	4.7777	3.1686	6.1717	21.1518	3.5914	5.1748	4.0430
$N\beta$	822.8	566.7	228.2	681.0	955.4	595.7	1617.0	2813.2	492.0	740.0	1152.2

individuals is small and the number of individuals divides evenly in each species. Therefore, he suggested that the index of total species diversity be used along with the index of species diversity.

Except for MEL-3, the value of Nß decreased from unburnt natural forests to opne fields. This suggests that the macro soil-animal community at each station became simpler under the influence of large fires and/or human impact.

2. Floor animals

A summary of results for floor invertebrates collected at each station is shown in Table 2.

The floor invertebrate fauna ranged through more taxonomic groups than the macro soil-animal fauna, and the total number of individuals was 1,831. Almost all of the individuals collected were ants, and so many species of ant were dominants at each station. If the piftall traps had been set near the nests and/or walking routes of ants, many ants might have been collected in the same trap throughout the days surveyed. However, the pitfall traps were not set near ant nests and not many ants were collected in each trap on the days surveyed.

Many arthropod groups of Araneae, Collembola, Orthoptera, Diptera, Coleoptera and Hymenoptera were collected widely with the pitfall traps not only in forests but also in open fields. Therefore, in the order level of taxon, the difference in floor arthropod faunas between the forests and open fields was not recognizable as was the difference in macro soil-animal faunas (Table 1).

A comparison was made of the degree of similarity of species composition, as collected with pitfall traps, for the stations of unburnt secondary forest, open fields of *Melastoma* shrub and *Imperata* grass, and the results are shown in Table 3. These three stations were located together within a short distance of about 100m in diameter. At each station, four pitfall traps were set and the collections were continued for ten days. The degree of similarity was expressed by Kimoto´s index of C_π(Kimoto,1967).

According to Table 3, the community structures of MEL and IMP of open fields were very similar. Meanwhile, that of USF differed from those of open fields. However, even at the same station, the similarity of species composition as collected with

Table 3. Comparison of the similarities between the floor invertebrate communities collected at different station of Km 37 (Total) and at each station (USF and MEL) expressed by Kimoto´s index of similarity. For abbreviations, see Fig. 1.

Total

MEL	0.340	
IMP	0.237	0.949
	USF	MEL

USF

2	0.790		
3	0.652	0.549	
4	0.541	0.472	0.967
	1	2	3

MEL

2	0.731		
3	0.711	0.343	
4	0.897	0.610	0.858
	1	2	3

Pitfall trap

four pitfall traps, differed. These facts, first of all, may be due to the difference in species composition of ants including some dominant ones.

The species and total species diversities of floor invertebrates were compared among the stations and the results are shown in Fig. 5.

The values of ß and Nß of MEL-3 were the largest, and so the complexity of fauna was not correlated with the difference in vegetation types. One of the reasons for this discrepancy may be the difference in ant fauna at each station, because the ants were the dominant group and the number of individuals was not so different from station to station as shown in Table 2. Thus, the

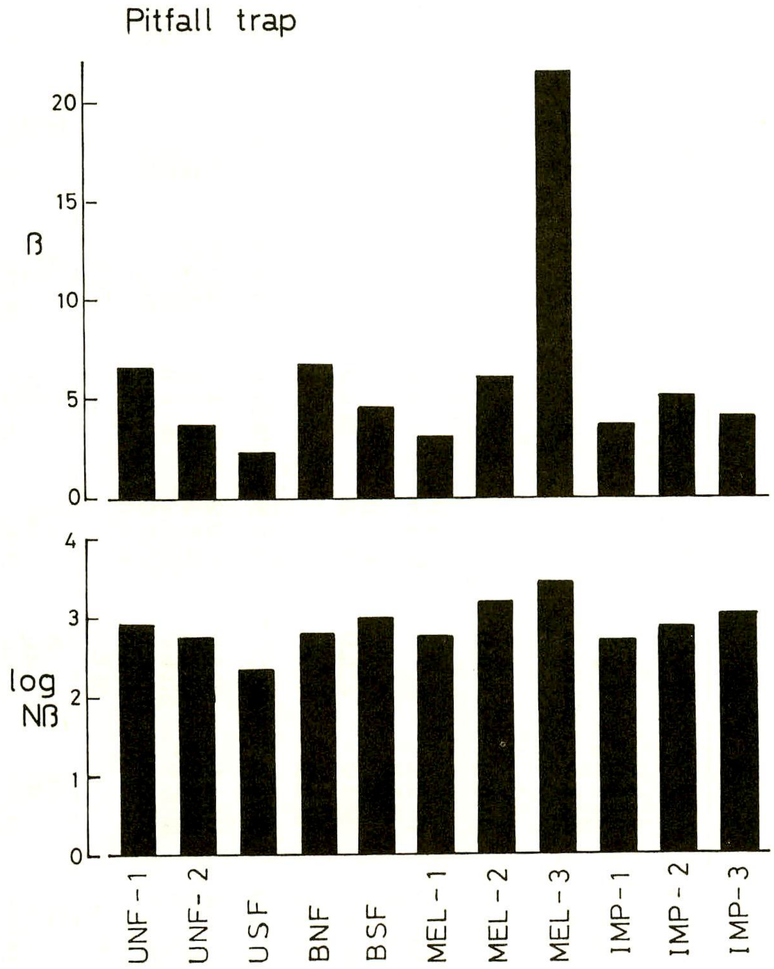

Fig. 5. Comparison of species diversity (ß) and total species diversity (Nß) of floor invertebrate communities at each station expressed by Morisita´s indexes. For abbreviations, see Fig. 1.

values of ß and Nß were influenced mainly by the species composition of ants. An example is MEL-3, where many species of ants with a small number of individuals, were collected.

3. Phytal animals

A summary of results for phytal invertebrates collected at each station is shown in Table 4.

The phytal invertebrate fauna was much more complex than the macro soil-animal and floor invertebrate fauna. At each station, some orders of taxon dominated and the total number of individuals collected was great, 6,019. Among the individuals,

Table 4. Number of species and percent composition (in parentheses) of phytal invertebrate communities at each station. For abbreviations, see Fig. 1.

Animals	UNF-1	UNF-2	USF	BNF	BSF	MEL-1	MEL-2	MEL-3	IMP-1	IMP-2	IMP-3
Gastropoda	11(3.0)	9(1.8)	7(1.5)		1(0.1)						
Opiliones		1(0.2)			1(0.1)						
Acarina	1(0.3)			3(0.7)	1(0.1)						
Aranea	79(21.7)*	36(7.1)*	33(6.9)	20(4.8)	20(2.5)	212(16.9)*	126(13.3)*	94(18.5)*	56(24.7)*	34(10.2)	32(16.7)*
Isopoda	1(0.3)										
Diplopoda			1(0.2)								
Collembola	4(1.1)									1(0.3)	
Thysanura	5(1.4)	2(0.4)	1(0.2)	2(0.5)	1(0.1)	1(0.1)			1(0.4)		
Ephemeroptera		1(0.2)						1(0.2)			
Odonata		1(0.2)					1(0.1)				
Orthoptera	17(4.7)	32(6.4)	25(5.2)	46(11.1)*	47(5.9)	18(1.4)	46(4.9)	2(0.4)	21(9.3)	28(8.4)	28(14.6)
Phasmida		1(0.2)	10(2.1)	1(0.2)	1(0.1)					1(0.3)	
Dermaptera	1(0.3)						1(0.1)				
Dictyoptera	3(0.8)	15(3.0)	7(1.5)	11(2.7)	5(0.6)	8(0.6)	3(0.3)	2(0.4)	3(1.3)	8(2.4)	3(1.6)
Embioptera		1(0.2)									
Psocoptera		3(0.6)	1(0.2)	1(0.2)	2(0.2)						
Thysanoptera							2(0.2)				
Hemiptera	15(4.1)	10(2.0)	38(7.9)	18(4.3)	38(4.7)	283(22.5)*	273(28.9)*	124(24.4)*	69(30.4)*	105(31.6)*	44(22.9)*
Mecoptera	1(0.3)										
Lepidoptera	6(1.6)	6(1.2)	3(0.6)	2(0.5)	11(1.4)	8(0.6)	5(0.5)	23(4.5)	4(1.8)	3(0.9)	7(3.6)
Diptera	63(17.3)*	94(18.8)*	89(18.6)*	38(9.2)	85(10.6)*	42(3.3)	78(8.3)	10(2.0)	15(6.6)	46(13.9)	14(7.3)
Coleoptera	36(9.9)*	31(6.2)	75(15.7)*	38(9.2)	85(10.6)*	81(6.4)	122(12.9)*	35(6.9)	23(10.1)	44(13.3)	32(16.7)*
Hymenoptera	119(32.7)*	256(51.1)*	186(38.9)*	230(55.6)*	503(62.8)*	587(46.7)*	287(30.4)*	217(42.6)*	28(12.3)	62(18.7)*	29(15.1)
Larva	2(0.5)	2(0.4)	2(0.4)			7(0.6)	1(0.1)	1(0.2)			3(1.6)
Unknown				4(1.0)		9(0.7)			7(3.1)		
No. of species	191	235	251	208	246	188	258	134	118	165	105
No. of individuals	364	501	478	414	801	1256	945	509	227	332	192
β	24.3606	12.2422	17.8509	18.9098	14.2021	5.7631	27.8827	24.5324	92.2698	63.9651	75.1475
$N\beta$	8867.3	6133.3	8532.8	3933.2	11375.9	7238.5	26349.2	12487.0	20945.2	21236.4	14428.3

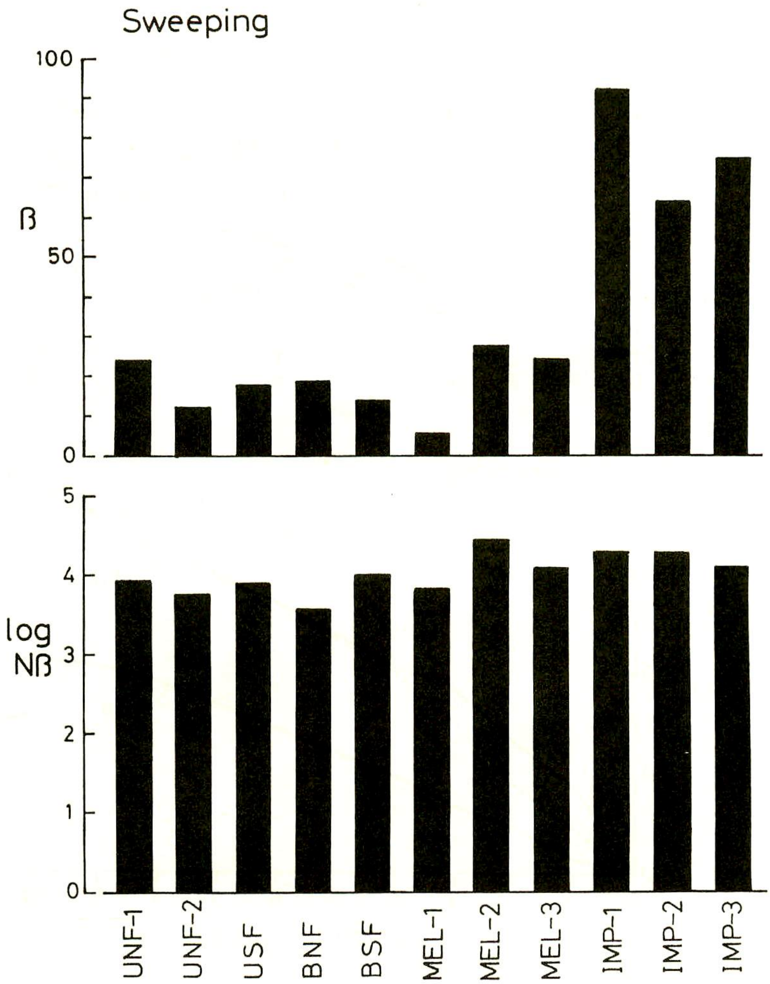

Fig. 6. Comparison of species diversity (ß) and total species diversity (Nß) of phytal invertebrate communities at each station expressed by Morisita´s indexes. For abbreviations, see Fig. 1.

many flower-visiting insects might have been collected because of *Melastoma* flowers being at their best. Many arthropod groups of Aranea, Orthoptera, Dictyoptera, Hemiptera, Lepidoptera, Diptera, Coleoptera and Hymenoptera were collected throughout all the stastions. However, except for ants which were collected dominantly not only in forests but also in open fields, Diptera and Coleoptera had a tendency to dominate in forests, and Aranea and Hemiptera in open fields. Moreover, it is interesting that some living land snails were collected, especially in unburnt forests.

The species and total species diversities of phytal invertebrates were compared among the stations and the results are

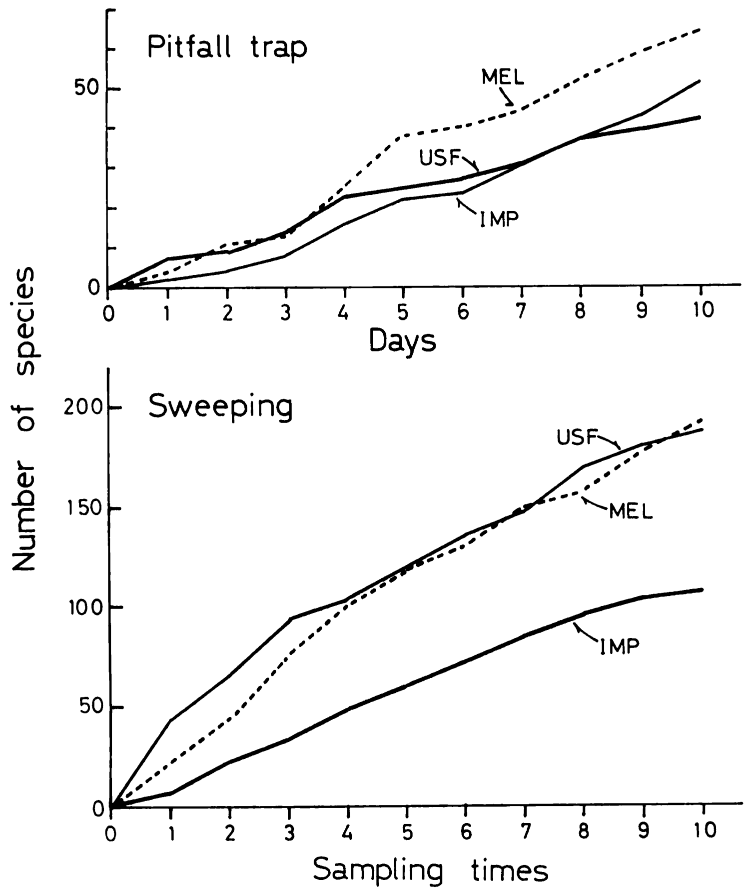

Fig. 7. Accumulative curve of number of species collected by pitfall traps and sweepings at each station of Km 37. For abbreviations, see Fig. 1.

shown in Fig. 6.

The values of ß in open fields of *Imperata* grass were higher than at other stations because of many species having a small number of individual each, whereas some dominant species, especially ants had a larger number of individuals, and so the values of ß were lower in forests and open fields of *Melastoma* shrub. Therefore, the values of total species diversity (Nß) were nearely similar among all the stations surveyed.

4. Conclusion

The fauna and biomass of macro soil-animals had a tendency to become more simple and smaller according to the change in vegetation after burning and/or logging (Table 1 and Figs. 2, 3, 4). However, such a tendency was not found in the results for the floor and phytal invertebrate communities (Tables 3, 4 and Figs. 5, 6).

Fig. 7 shows that, even if the number of species differed among the stations, more and more new species were recruited with an increase in collection. This suggests that the faunas of floor and phytal invertebrates not only in forests but also in open fields may be rich and complex. Therefore, the diversities of floor and phytal community structure will be affected largely by the difference in number of individuals of dominant species.

Termites play an important role in flow of energy and cycling of nutrients, and are economically and ecologically an important aspect of tropical ecosystems just as earthworms are. In the same East Kalimantan, Aoki and Harada (1982) reported that many termite species and individuals were collected widely from natural forests to shifting cultivated fields. However, in the area of the Kutai National Park observed in this study, termites and their mounds were difficult to find, and only three individuals were collected in the pitfall traps in the burnt natural forests (Table 2). The reason for the poverty of the termite fauna in the area studied is not clear at this time and more survey work is necessary.

As a result of this study, it was concluded that the diversity of terrestrial invertebrates recovers within three years after large fires. But the fauna after burning cannot be assumed to be the same as the fauna before burning.

The burnt forests surveyed were located close to the unburnt forests (Fig. 1) , and so many species and individuals such as migratory insects may able to immigrate easily into the burnt forests from the unburnt forests. This assumption is supported by the fact that the dominant ants such as *Anoplolepis longipes* (Jerdon), *Leptogenys* sp. and *Crematogaster* sp. were found widely in the various vegetation types, where they were collected with the pitfall traps and sweepings. On the other hand, most of the land snails which cannot migrate easily will be damaged by burning and as a result, these snails survived and were collected at the unburnt forests (Tables 1, 2, 4).

Therefore, studies on the change in structure of the terrestrial invertebrate community in relation to burning and logging will be necessary for more detailed investigation among the various vegetations, not only of the diversity of fauna but also of characteristic species such as land snails.

V. ACKNOWLEDGEMENTS

I am pleased to acknowledge the considerale assistance of Mr. F. Ellia G. of Provincial Goverment of East Kalimantan during the field researches and also wish to express my gratitude to Professor H. Tagawa of Kagoshima University, who is the leader of the joint party, and Dr. N. Wirawan of Hasanuddin University for their many helpful suggestions and criticisms throughout the course of my work. Thanks are also due to all the members of the joint party for their kind support in my work and Dr. S. Yamane of Kagoshima University for the identification of ants. I should like to express my grateful thanks to the Indonesian Institue of Sciences (LIPI), Dr. S. Adisoemarto and Dra. R. Suhardjono of Bogor Zoological Museum, and many staffs of administrative office of the Kutai National Park. This study was supported by Grant-in-Aid for overseas Scientific Survey from the Ministry of Education, Science and Culture (Nos.61041067 and 62043063).

VI. SUMMARY

1. To know the change and recovery of terrestrial invertebrate community in the tropical rain forest after large fires, the research was done at the Kutai National Park in East Kalimantan (Borneo), Indonesia, in July to August 1986.

2. After consideration of the influence of large fires and the human impact on nature, eleven stations were selected from the unburnt natural forests, unburnt secondary forest, burnt natural forest, burnt secondary forest, and open fileds of *Melastoma* shrub and *Imperata* grass.

3. The fauna of macro soil-animals, floor animals and phytal animals were studied at each station.

4. The fauna of macro soil-animals was generally poverty in each station, and according to the impacts of fires and human disturbance, the density, biomass and fauna of macro soil-animals became simpler.

5. No clear relationship was found between the faunas of

floor and phytal invertebrates, and the environmental divisions.

One of the reasons of these discrepancies in relation to the environmental divisions was due to the difference of number of species and individuals of ants which dominated in the floor and phytal invertebrate communities at each station.

6. It may be said that the terrestrial invertebrate community recovered quickly beyond exceptation in the tropical rain forests after burning.

VII. REFERENCES

Aoki, J. and H. Harada (1982) Environmental change and soil fauna in East Kalimantan (Borneo). Bulletin of the Institue of Environmental Science and Technology, Yokohama National University, 8:341-378. (In Japanese with English summary).

Katō, M., T. Matsuda and Z. Yamashita (1952) Associative ecology of insects in the paddy field cultivated various planting forms. Science Report of Tōhoku University, Series IV (Biology), 19:291-301.

Kimoto, S. (1967) Some quantitative analysis on the Chrysomelid fauna of the Ryukyu Archipelago. Esakia, 6:27-54.

Kira, T. (1983) Nettai-rin no seitai (Ecology of tropical forests). 251pp. Jinbun-syoin, Kyoto, Japan. (In japanese).

Lal, R. (1987) Tropical ecolgy and physical edaphology. 732pp. John Wiley & Sons, Chichester, Great Britain.

Leighton, M. (1984) The impact of one of the world´s worst forest fires. WWF Monthly Report June, pp.115-123.

Malingreau, J.P., G. Stephens and L. Fellows (1985) Remote sensing of forest fires: Kalimantan and North Borneo in 1982-83. Ambio, 14:314-321.

Morisita, M. (1967) Kyoto fukin ni okeru chyō no kisetu-bunpu (Seasonal distribution of butterflies near Kyoto). In Morisita, M. and T. Kira (eds.), Sizen:Seitaigau-teki-kenkyu (Nature:Ecological studies), pp.95-132. Chuokoron-sha, Tokyo, Japan. (In Japanese).

Watanabe, H.,P. Saichuae and T. Shidei (1966) On the biomass of of soil animals found in various types of forests in Thailand. Southeast Asian Studies, 4:133-139.

Watanabe, H., S.Ruayssongnern and H. Takeda (1983) Soil animals. In Kyuma, K. and C. Pairintra (eds.), Shifting Cultivation, pp.110-126, Ministry of Science, Technology and Energy, Banghkok, Thailand.

Wirawan, N. (1984) Kutai National Park and the great Kalimantan fire. WWF Monthly report June, pp.125-132.